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(54) **MEDICAL INSTRUMENT AND PRODUCTION THEREOF.**

(57) This invention relates to a medical instrument having a cylindrical member and a member which slides while keeping a close contact with the inner wall of the cylindrical member, wherein a lubricating film (7) which has durability and is not easily peeled off is formed on a thermoplastic elastomer layer of at least that portion of the sliding member (5) which comes into contact with the cylindrical inner wall by low-temperature plasma polymerization of a thermoplastic synthetic resin having a low kinetic frictional coefficient in a monomer atmosphere so that the sliding member can be fitted smoothly into the cylindrical member and can slide smoothly inside the cylindrical member. The invention also relates to a method of production of such a medical instrument.

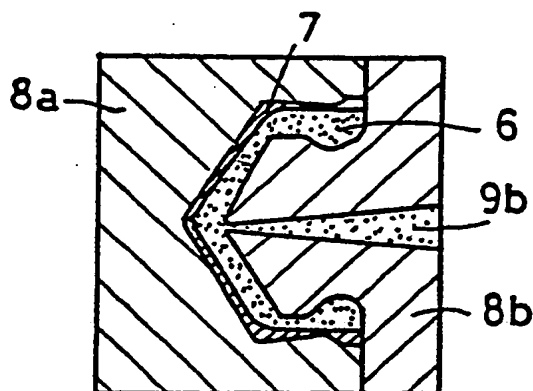


Fig. 5.

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S P E C I F I C A T I O N

Medical instrument, and method of
manufacturing the same

Technical Field

The present invention relates to a medical instrument, and in particular to a disposable syringe which can be assembled without using a lubricant, and a method
5 of manufacturing the same.

Background Art

A disposable syringe comprises a barrel and a plunger which can be slidably inserted in the barrel. A gasket is mounted at the distal portion of the plunger
10 so as to assure air-tightness between the barrel and the plunger.

Typical examples of a material of the barrel and the plunger are polypropylene and poly(4-methylpentene-1). The gasket is prepared from natural rubber (NR),
15 butyl rubber (IIR), styrene-butadiene rubber (SBR), acrylonitrile-butadiene rubber (NBR), or the like by means of a vulcanizing press-molding. As an alternative method of preparing a gasket, a thermoplastic elastomer such as a styrene-butadiene-styrene block copolymer
20 (SBS), a styrene-ethylene-butylene-styrene block copolymer (SEBS), or an ethylene-propylene copolymer (EP) may be injection-molded.

When the barrel made of the above material is combined with the gasket made of the above material,

a considerably high friction resistance is generated at a contact portion between the barrel and the gasket. In this state, the plunger cannot be slid inside the barrel. In the worst case, it is very difficult to
5 assemble a disposable syringe by inserting the plunger into the barrel.

In conventional syringe assembly, a lubricant such as silicone oil is applied to the contact portion between the barrel and the gasket. In this case, however,
10 the lubricant may be leaked out and mixed with a liquid in the syringe even though the amount thereof may be very small. Accordingly, the use of the lubricant is undesirable since the syringe is used to inject a drug into a human body. For this reason, a demand has arisen
15 for a disposable syringe which allows a plunger to easily slide without using a lubricant.

It is a first object of the present invention in consideration of the above situation to provide a medical instrument, in particular a disposable syringe which
20 allows slidable movement of a plunger without using a lubricant.

It is a second object of the present invention to provide a gasket suitable for achieving the first object, and a method of manufacturing the same.

25 Disclosure of Invention

In order to achieve the first object of the present invention, it is suitable to use a lubricious material which cannot be mixed with a liquid in a syringe. A lubricating treatment free from elution of the lubricant
30 on the surface of a gasket is performed according to the present invention.

A medical instrument according to the present invention comprises a cylindrical member and a sliding member which is adopted to slide along the inner wall of
35 the cylindrical member, wherein the sliding member comprises a thermoplastic elastomer layer and a thermoplastic resin layer of a low dynamic friction

coefficient covering a portion of the elastomer which contacts with the inner wall of the cylindrical member.

5 A disposable syringe according to the present invention comprises: a synthetic resin barrel, one end of which has a nozzle and the other end of which is open; a synthetic resin plunger which is inserted into the barrel from the open end thereof and is slidable along an inner wall surface of the barrel; and a gasket mounted at a front end portion of the plunger so as to assure air-tightness between the plunger and the inner wall surface of the barrel, wherein an area of a surface of the gasket which is brought into contact with the inner wall surface of the barrel is covered with a film. The thickness of the lubricating film formed on the gasket surface falls within the range of 30 μm or less, preferably 10 μm or less, and more preferably 5 μm or less. A preferable material of the lubricating film is a fluoroplastic material.

20 The gasket according to the present invention is mounted in contact with the inner wall surface of the barrel of the syringe and can be slid along the inner wall surface. The gasket comprises a gasket body made of an elastic material and having a predetermined shape, and a lubricating film formed on a gasket surface portion which is in slidable contact with the inner wall surface of the barrel.

30 A method of manufacturing the gasket mounted in contact with the inner wall surface of the barrel of the syringe so as to slide along the inner wall surface according to the present invention is characterized in that a gasket body made of an elastic material and having a predetermined shape is placed in a monomer gas atmosphere, and a plasma is generated in the atmosphere to perform low-temperature plasma polymerization of the monomer, thereby forming a lubricating film on a surface of the gasket body.

35 It is known that a fluoroplastic material has low

adherence and a small friction coefficient as compared with other resin materials and is used in various types of sliding surfaces and bearings. Of all fluoroplastic materials, polytetrafluoroethylene (PTFE) and a
5 tetrafluoroethylene-hexafluoropropylene copolymer (FEP) are known as resin materials having a small dynamic friction coefficient.

Since a gasket coated with a resin having excellent lubricating properties is used in the syringe according
10 to the present invention, the plunger can be easily inserted into the barrel during syringe assembly. In addition, during an application of the syringe, the plunger can be freely slid in the barrel without problems.

15 The fluoroplastic material is not dissolved in the liquid in the syringe, thus assuring safety in injection of a drug into a human body.

The fluoroplastic thin film formed on the gasket body by low-temperature plasma polymerization has high
20 adhesion strength and cannot be easily peeled from the gasket.

In addition, the thickness of the lubricating film formed on the surface of the gasket body according to low-temperature plasma polymerization can be easily
25 controlled.

Brief Discription of Drawings

Fig. 1 is a partial sectional view of a disposable syringe according to an embodiment of the present invention;

30 Fig. 2 is a partial sectional view of a gasket used in the disposable syringe shown in Fig. 1;

Fig. 3 is a partial sectional view of a gasket according to another embodiment of the present invention;

35 Figs. 4 and 5 are sectional views showing a method of preparing a gasket of the present invention by using a two-color injection molding method;

Fig. 6 is a schematic view showing a plasma polymerization apparatus used in the manufacture of a gasket of the present invention; and

5 Figs. 7A, 7B and 7C are sectional view illustrating a method of manufacturing a gasket by using another method according to the present invention.

Best Mode for Carrying out the Invention

The present invention will be described in detail with reference to preferred embodiments.

10 Fig. 1 is a partial sectional view of a disposable syringe according to an embodiment of the present invention. Referring to Fig. 1, reference numeral 1 denotes a synthetic resin barrel. Nozzle 2 is formed at the front end of barrel 1. A needle cannula is fitted on
15 the nozzle when the syringe is used. The rear end of barrel 1 is open, and finger flange 3 is formed at the edge of the open end. Synthetic resin plunger 4 with a thumb rest is inserted inside barrel 1 from its rear end opening. Gasket 5 is mounted on the front end of
20 plunger 4. Gasket 5 is brought into tight contact with the inner wall surface of barrel 1, thereby assuring air-tightness. A lubricating film (not shown) is formed on the surface of gasket 5. This lubricating film provides excellent sliding properties to gasket 5 slid
25 along the inner wall surface of barrel 1. The details of the respective parts will be described below.

A material for barrel 1 and plunger 4 is preferably transparent and has good moldability and high impact strength. Examples of the preferable synthetic resin
30 are polypropylene, poly(4-methylpentene-1), high-impact strength polystyrene, and polycarbonate. A more preferable material is polypropylene or poly(4-methylpentene-1).

35 Fig. 2 is an enlarged view showing a partial section of gasket 5. Referring to Fig. 2, reference numeral 6 denotes a gasket body. As shown in Fig. 2, the gasket body has a mushroom-like shape and has

a recess for receiving the front end of plunger 4.

Lubricating thin film 7 of a fluoroplastic material is formed on the surface of the gasket body. Fluoroplastic lubricating thin film 7 need not be formed on the entire surface of gasket body 6. As shown in Fig. 3, the film may be formed on gasket portions which are brought into sliding contact with the inner wall surface of barrel 1.

Gasket body 6 can be formed by injection-molding a thermoplastic elastomer. Alternatively, gasket body 6 may be formed by vulcanizing press-molding a raw rubber material. The thermoplastic elastomer may be one of the SBS, SEBS, EP, polyester, and polyurethane elastomers. At least one of the SEBS and EP elastomers is preferably used. At least one of butyl rubber, SBR, EPR, NBR, natural rubber, isoprene rubber, chloroprene rubber, and fluoro rubber is used as a cured rubber material. Preferably, at least one of SBR, NBR, natural rubber, and isoprene rubber is used.

A compression set (JIS K-6301) of gasket body 6 (at 70°C for 22 hours) is given to be 60% or less and preferably 50% or less. If the compression set exceeds 60%, the gasket is distorted such that the diameter of the gasket becomes equal to the inner diameter of the barrel. When this gasket is slid in the barrel, the peak portion of the gasket is separated from the inner wall surface of the barrel, and air-tightness cannot be assured.

A hardness value (JIS K-6301) of rubber used as gasket body 6 preferably falls within the range of 35° to 85° in JIS-A. If the hardness value exceeds 85°, it is difficult to assemble the syringe. However, if the hardness value is less than 35°, the gasket is deformed during sliding movement and it is difficult to slide the gasket body. The rubber hardness value more preferably falls within the range of 40° to 70°. At least one of SBS, SEBS, and EP copolymers having the compression set and rubber hardness values which fall within the above

ranges is preferably used as a thermoplastic elastomer for a material of gasket body 6.

If the thickness of lubricating thin film 7 is excessively large, the hardness of the coated portion is too high, and air-tightness in the syringe cannot be maintained. Therefore, the thickness of lubricating thin film 7 falls within the range of 30 μm or less, preferably 10 μm or less, and more preferably 5 μm or less.

Lubricating thin film 7 preferably has a friction coefficient of 0.5 or less when it is slid along steel. If this friction coefficient exceeds 0.5, a sliding resistance value of plunger 4 is excessively increased, and the syringe cannot properly function. The sliding resistance value is defined as follows. When a plunger in an empty syringe without a needle cannula is pushed into the barrel at a predetermined speed from a maximum scale marking position to a marking position representing 10% of the maximum volume of the syringe, an initial resistance value is subtracted from the resultant resistance value. This test is repeated and differences are then averaged to obtain the "sliding resistance value".

Adhesion strength of lubricating thin film 7 on the surface of gasket body 6 falls within the range of 80/100 to 100/100 in a checkerboard test (JIS D-0202) and preferably 95/100 to 100/100. If the adhesion strength is less than 80/100, the following defect occurs. When plunger 4 is slid in the barrel, lubricating thin film 7 may be peeled from gasket body 6 since the adhesion strength between lubricating thin film 7 and gasket body 6 is weak.

Examples of the material for the lubricating thin film upon consideration of the above factors are polytetrafluoroethylene (PTFE), polyvinylidene fluoride (PVDF), polytetrafluoroethylene containing a perchloroalkoxy side chain (PFA),

polychloro-trifluoroethylene, a tetrafluoroethylene-hexafluoropropylene copolymer (FEP), a polyvinylethylene fluoride-ethylene tetrafluoride copolymer, high-density polyethylene (HDPE), low-density polyethylene having a very high molecular weight, and a material containing at least one thereof.

According to the disposable syringe having the structure described above, when the plunger is slid in the barrel, an slide resistance value which allows normal use of the syringe can be obtained so that the syringe can be suitably used. It should be noted that the slide resistance value which allows normal use of the syringe is 1.8 kgf or less at a pushing speed of 200 mm/sec, although it depends on the syringe size.

A method of manufacturing gasket 5 will be described below. The following various methods can be used to manufacture gasket 5.

(A) A two-color injection molder is used to form lubricating thin film 7 by using resin 9a (e.g., polyvinylidene fluoride or high-density polyethylene) having good injection molding properties and a low dynamic friction coefficient, as shown in Fig. 4. Gasket body 6 is formed by using thermoplastic elastomer resin 9b, as shown in Fig. 5. In this case, in order to improve adhesion strength between gasket body 6 and lubricating thin film 7, a resin having a low dynamic friction coefficient may be added as thermoplastic elastomer resin 9b. Alternatively, an adhesive may be applied to the inner surface of lubricating thin film 7 prior to molding of a second color. Reference numerals 8a and 8b in Figs. 4 and 5 denote molds, respectively.

(B) A powder of a resin (e.g., fluoroplastic or polyethylene having a very high molecular weight) having a low dynamic friction coefficient providing poor fluidity is applied to molds, and subsequently a thermoplastic elastomer is injection-molded. In this case, in the same manner as in method (A), adhesion

strength between gasket body 6 and lubricating thin film 7 can be improved.

(C) As shown in Figs. 7A, 7B and 7C, a resin having a low friction coefficient is formed into a film, and the film is vacuum- or compression-molded in the molds. A thermoplastic elastomer is then injection-molded on the molded film. In the same manner as in method (A), adhesion strength between gasket body 6 and lubricating thin film 7 can be improved.

(D) Gasket body 6 is molded, and lubricating thin film 7 is formed on the surface of body 6 by powder coating, dispersion coating, or solution coating.

(E) A layer of a resin having a low dynamic friction coefficient is laminated on a thermoplastic elastomer sheet by using an adhesive, and the resultant laminated body is molded by compression molding or the like.

A most preferable method of manufacturing the gasket is the following method using low-temperature plasma polymerization. According to this method, lubricating thin film 7 is formed on the surface of gasket body 6 by using low-temperature plasma polymerization. More specifically, gasket body 6 is placed in a monomer gas atmosphere for forming a lubricating thin film by polymerization, and a low-temperature plasma is generated upon application of an RF voltage. Active seeds are produced from the monomer by the behavior of the low-temperature plasma. These active seeds are reacted with each other to perform polymerization, thereby forming a lubricating polymer. This polymer is attached to and deposited on the surface of gasket body 6, and therefore lubricating thin film 7 is formed. The most preferable monomer gas in this method is a fluorine-containing monomer gas such as tetrafluoromethane, hexafluoroethylene, trifluoromethane, or pentafluoroethane.

The effects of the present invention will be

described in detail by way of its examples and comparative examples.

Examples 1 - 22

5 Lubricating thin films 7 of a fluoroplastic material were formed on surfaces of cured rubber gasket bodies 6 by plasma polymerization, respectively (Examples 1 to 11). Each cured rubber gasket body 6 was prepared such that 30 parts by weight of carbon black HAF, 1.5 parts by weight of sulfur, 3.0 parts by weight of zinc, 0.5 parts by weight of stearic acid, and proper amounts of a curing accelerator, a curing assistant agent, and an antioxidant were added to styrene-butadiene rubber SOLPRENE 1204 (tradename) available from Nippon Elastomer K.K., and the resultant mixture was subjected to a vulcanizing press-molding at 140°C for 30 minutes. The resultant molded body was punched to prepare each cured rubber gasket body 6. In addition, 35 parts by weight of carbon black HAF, 2.3 parts by weight of sulfur, 5 parts by weight of zinc white, 2 parts by weight of stearic acid, and the proper amounts of a curing accelerator, a curing assistant agent, and an antioxidant were added to isoprene rubber JSR-IR-2200 (tradename) available from Nippon Gosei Gomu K.K., and the resultant mixture was cured and press-molded at 135°C for 30 minutes. The resultant molded body was punched to prepare a gasket body.

Gasket bodies 6 (Examples 12 to 22) were prepared by thermoplastic elastomers, following the same procedures as in Examples 1 to 11. These thermoplastic elastomer gasket bodies were prepared by injection-molding an SEBS thermoplastic elastomer AR-804 (tradename) available from Aron Kasei K.K., and an EP thermoplastic elastomer Milastomer 5510B (tradename) available from Mitsui Petrochemical Industries, Ltd.

35 Each gasket body 6 was placed in a reaction chamber, and the chamber was evacuated by a vacuum pump to a vacuum of 1 Torr or less. In this case, the

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reaction chamber may be of a flow, bell jar, or any other type. After evacuation was satisfactorily performed, fluorine-containing molecules were introduced in the chamber in the form of a gas, and the reaction chamber was kept in a vacuum of 10^{-3} to 10 Torr and preferably 10^{-2} to 5 Torr. The fluorine-containing molecules are selected from at least one of tetrafluoromethane, trifluoromethane, monochlorotrifluoromethane, hexafluoroethane, pentafluoroethane, monochloropentafluoroethane, and cycloheptafluorobutane. Preferably, at least one of tetrafluoromethane, trifluoromethane, hexafluoromethane, pentafluoroethane, and cycloheptafluorobutane is used. A plasma was generated in the reaction chamber upon application of an RF voltage while the chamber was kept at a predetermined pressure. Immediately after initiation of a reaction, polymerization occurred to form a thin film. However, a period of time required for forming a thin film having required lubricating properties varies depending on a vacuum pressure, a voltage, a monomer seed, and a monomer flow rate. Therefore, no specific reaction conditions are defined. Conditions employed in Examples 1 to 22 are summarized in Tables 1 and 2. Upon completion of the reaction, each gasket was removed after the internal pressure of the reaction chamber was returned to the atmospheric pressure.

A power source for applying the RF voltage was a combination of an RF power source SKN-05-P (tradename) and a matching box MB-500 (tradename) available from Nihon Koshuha K.K., and copper wires and copper mesh were used. Freon 14, Freon 116, and Freon 23 (tradename) available from Mitsui Fluorochemical K.K. were used as tetrafluoromethane, hexafluoroethylene, and trifluoromethane, all of which were used as monomers of fluorine-containing molecules, respectively.

Disposable syringes (Fig. 1) were assembled using the gaskets prepared in Examples 1 to 22. Polypropylene

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MG-3D (tradename) available from Mitsubishi Petrochemical Co., Ltd. and poly(4-methylpentene-1) RT-18 (tradename) available from Mitsui Petrochemical Industries, Ltd. were injection-molded to prepare
5 barrels 1 and plungers 4. Surface-treated plungers 4 were engaged with corresponding gaskets 5 and were inserted in corresponding barrels 1, thereby preparing syringes. Sliding resistance values were measured when
10 plungers 4 were slid along the inner wall surfaces of corresponding barrels. Measurement of sliding resistance values was performed by using a compression jig Strograph-T (tradename) available from Toyo Seiki K.K. at a pushing speed of 200 mm/sec. Results are
15 shown in Tables 1 and 2. Table 1 shows the results of cured rubber gaskets, while Table 2 shows the results of thermoplastic elastomer gaskets.

As comparative examples 1 to 8, syringes were assembled using gaskets without plasma polymerization, following the same procedures as in Examples 1 to 22.
20 The sliding resistance values were very large, and plungers could not be fitted in the barrels.

The volume of each disposable syringe used in each example described above was 5 ml, but is not limited to this volume.

Table 1

	Type of Monomer	Vacuum Pressure (Torr)	Applied voltage (V)	Time (min.)	Gasket Material	Barrel Material	Sliding Resistance (kgf)	Remarks
Example 1	CF ₄	0.5	100	20	SBR	PP	0.30	
"	"	"	"	"	"	TPX	0.29	
"	"	"	"	"	IR	PP	0.30	
"	"	1	50	"	SBR	"	0.30	
"	"	"	"	30	"	"	0.26	
"	"	"	100	20	"	"	0.19	
"	"	2	"	"	"	"	0.16	
"	CF ₃ ·CF ₃	0.5	"	"	"	"	0.33	
"	"	"	"	10	"	"	0.38	
"	CHF ₃	"	"	20	"	"	0.50	
"	"	"	"	30	"	"	0.43	

(Continued)

	Type of Monomer	Vacuum Pressure (Torr)	Applied voltage (V)	Time (min.)	Gasket Material	Barrel Material	Sliding Resistance (kgf)	Remarks
Comparative Example 1	-	-	-	-	SBR	PP	Assembly failed	No plasma treatment
" 2	-	-	-	-	"	TPX	"	"
" 3	-	-	-	-	IR	PP	"	"
" 4	CF ₄	15	150	60	SBR	"	"	No plasma generation

Table 2

	Type of Monomer	Vacuum Pressure (Torr)	Applied Voltage (V)	Time (min.)	Gasket Material	Barrel Material	Sliding Resistance (kgf)	Remarks
Example 12	CF ₄	0.1	100	20	SEBS	PP	0.37	
" 13	"	0.5	"	"	"	"	0.27	
" 14	"	"	"	30	"	"	0.23	
" 15	"	1	"	20	"	"	0.16	
" 16	"	0.5	"	"	"	TPX	0.15	
" 17	"	1	"	"	EP	PP	1.29	
" 18	"	0.5	"	"	"	"	0.19	
" 19	CF ₃ •CF ₃	"	"	"	SEBS	"	0.29	
" 20	"	"	"	10	"	"	0.34	
" 21	CHF ₃	"	"	20	"	"	0.48	
" 22	"	"	"	30	"	"	0.40	

(Continued)

	Type of Monomer	Vacuum Pressure (Torr)	Applied Voltage (V)	Time (min.)	Gasket Material	Barrel Material	Sliding Resistance (kgf)	Remarks
Comparative Example 5	-	-	-	-	SEBS	PP	Assembly failed	No plasma treatment
" 6	-	-	-	-	EP	"	"	"
" 7	-	-	-	-	SEBS	TPX	"	"
" 8	CF ₄	15	150	60	"	PP	"	No plasma generation

Example 23

Gasket body 6 was prepared by injection-molding SEBS thermoelastic elastomer AR-804 (tradename) available from Aron Kasei K.K., and a fluoroplastic material was coated on the surface of gasket body 6 by plasma polymerization. Coating of the fluoroplastic material was performed using the plasma polymerization apparatus in Fig. 6 as follows.

A monomer gas stored in monomer gas tank 10 was supplied to reaction chamber 12 through flow control valve 11. Reaction chamber 12 was evacuated by a vacuum pump through vacuum gauge 13. RF power source 14 and matching box 15 were connected to reaction chamber 12 through copper mesh 16. In Example 23, an SKN-05P (tradename) available from Nihon Koshuha K.K. and an MB-500 available from Nihon Koshuha K.K. were used as RF power source 14 and matching box 15, respectively. Tetrafluoromethane Freon 14 (tradename) available from Fluorochemical K.K. was used as a monomer gas. When plasma polymerization was performed, the reaction chamber was set in a vacuum of 1 Torr and a voltage of 100 V was applied thereto for 20 minutes.

The gasket surface-treated by the above plasma polymerization was cut, and the thickness of a film formed thereon was measured to be 0.3 to 0.5 μm by a scanning electron microscope JSM-840 (tradename) available from Nihon Denshi K.K.

A plate made of the same thermoplastic elastomer as that of the gasket was plasma-polymerized and a dynamic friction coefficient (with respect to steel) of a film formed on the plate was measured to be 0.4. A checker-board test was conducted using a plate as in the plate obtained above, and a measurement value was 100/100.

A disposable syringe was assembled using the above gasket and barrel 1 and plunger 4. In this case, barrel 1 and plunger 4 were prepared by injection-molding MG-3D (tradename) available from Mitsubishi Petrochemical Co.,

Ltd. A peak diameter of the gasket was 13.2 mm and an inner diameter of the barrel was 13.0 mm. As a result, the disposable syringe could be easily assembled without using a lubricant.

5 The resultant syringe was sterilized with gamma rays of 2.0 Mrad using Co (cobalt) having a molecular weight of 60 as a ray source. A 22-G cannula was attached to the nozzle of the syringe, and 5 ml of physiological saline Terumo Seishoku (tradename)
10 available from Terumo K.K. was drawn into the syringe and injected in a vein of a dog. The syringe could be properly used without problems.

Example 24

15 A surface-treated gasket was prepared following the same procedures as in Example 23 except that hexafluoroethane Freon 116 (tradename) available from Mitsui Fluorochemical K.K. was used as a monomer for plasma polymerization. The same results as in the measurement of the film thickness and the checkerboard
20 test in Example 23 were obtained. A dynamic friction coefficient (with respect to steel) was 0.5. No problems occurred in assembly of a disposable syringe, gamma-ray sterilization, and venous injection to a dog.

Example 25

25 A surface treatment was performed by plasma polymerization following the same procedures as in Example 23 except that a gasket body was prepared by adding 30 parts by weight of carbon black HAF, 1.5 parts by weight of sulfur, 3.0 parts by weight of zinc white, 0.5 parts
30 by weight of stearic acid, and proper amounts of a curing accelerator, a curing assistant agent, and an antioxidant to Solprene 1204 (tradename) available from Nihon Elastomer K.K., curing and press-molding the resultant mixture at 141°C for 30 minutes, and punching
35 the resultant molded body. A measurement and a test were conducted following the same procedures as in Example 23.

The same results as in measurement of the film thickness, the checkerboard test, and measurement of the dynamic friction coefficient as in Example 23 were obtained. No problems occurred in syringe assembly, gamma-ray sterilization, and venous injection to a dog. Comparative Example 9

No plasma was produced when a voltage was applied following the same conditions as in Example 23 and using the same apparatus and gasket material as in Example 23, except that a monomer was not supplied. No change on the surface of the gasket. Syringe assembly was impossible without a lubricant.

Comparative Example 10

A plasma was produced in a vacuum of 0.08 Torr following the same procedures as in Comparative Example 9. However, no change occurred on the gasket surface in the absence of a monomer gas. Syringe assembly was impossible without a lubricant.

Example 26

A cured SBR gasket material as in Example 25 was degreased with isopropanol, and polytetrafluoroethylene enamel Polyfron Toughcoat Enamel TC-7400 available from DAIKIN INDUSTRIES, LTD. was coated to a peak portion shown in Fig. 2 and was preliminarily dried at 80°C for 30 minutes. The dried film was sintered at 180°C for 30 minutes. A measurement and a test of a disposable syringe using the resultant gasket was performed following the same procedures as in Example 23. The gasket was cut and a cut surface was observed with a scanning electron microscope. The film had a thickness of 18 to 25 μm . An adhesion strength based on a checkerboard test was 100/100. A dynamic friction coefficient (with respect to steel) was 0.1. A disposable syringe was easily assembled without a lubricant by using this gasket and a barrel and a plunger which latter two were obtained as in Example 3. No problems occurred in gamma-ray sterilization and venous injection

to a dog.

Comparative Example 11

5 A barrel, a plunger, and a gasket material as in Example 26 were used to assemble a disposable syringe without coating polytetrafluoroethylene to the gasket material. In this case, assembly was impossible without a lubricant. A dynamic friction coefficient was 3.0.

Example 27

10 A 5-ml syringe gasket having a peak diameter of 13.2 mm was injection-molded using an SEBS elastomer AR-804 available from Aron Kasei K.K. 15% by weight of a polyvinylidene fluoride resin KYNAR #301F available from Pennwalt Corp. were dissolved in a 4 : 1 (weight ratio) solvent mixture of acetone and dimethylformamide to prepare a coating solution. The gasket was dipped in the resultant coating solution. The gasket was then dried at room temperature for half a day and at 60°C for an hour, thereby forming a polyvinylidene fluoride film on the surface of the gasket. A plunger obtained by polypropylene MG-3D available from Mitsubishi Petrochemical Co., Ltd. was engaged with the gasket with the polyvinylidene fluoride film. The resultant structure was inserted in a 5-ml syringe barrel having an inner diameter of 13.0 mm, thereby obtaining a disposable syringe. The disposable syringe could be assembled without using lubricating silicone oil. A sliding resistance value was 0.25 kgf at a pushing speed of 200 mm/sec. The gasket with the polyvinylidene fluoride film was cut, and the thickness of a film on the cut portion was measured following the same procedures as in Example 23. The thickness was 30 to 25 μ m. Venous injection to a dog was performed using this disposable syringe, following the same procedures as in Example 23. The disposable syringe could be properly used, and no problems occurred. No peeling of the film from the gasket was found.

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Example 28

A disposable syringe was assembled and measurements thereof were performed, following the same procedures as in Example 27 except that 10% by weight of a polyvinylidene fluoride resin KYNAR #7201 available from Pennwalt Corp. were dissolved in acetone. A sliding resistance value was 0.23 kgf, and a film thickness was 20 to 25 μm . Normal use was allowed in venous injection to a dog. No peeling of the film was found.

Example 29

A disposable syringe was assembled and measurements thereof were performed, following the same procedures as in Example 27 except that 8% by weight of a polyvinylidene fluoride resin KYNAR #7201 available from Pennwalt Corp were dissolved in a 1 : 1 (weight ratio) solvent mixture of methyl ethyl ketone and acetone. A sliding resistance value was 0.22 kgf, and a film thickness was 18 to 24 μm . Normal use was allowed in venous injection to a dog as in Example 23. No peeling of the film was found.

Example 30

A disposable syringe was assembled, and measurements and venous injection to a dog were performed following the same procedures as in Example 27 except that an EP elastomer Milastomer 5510 available from Mitsui Petrochemical Industries, Ltd. The same results as in Example 27 were obtained.

Example 31

A disposable syringe was assembled following the same procedures as in Example 28 except that 35 parts by weight of carbon black HAF, 2.3 parts by weight of sulfur, 5 parts by weight of zinc white, 2 parts by weight of stearic acid, and proper amounts of a curing accelerator, a curing assistant agent, and an were added to 100 parts by weight of isoprene rubber JSR-IR-2200 available from Nihon Gosei Gomu K.K. and the resultant mixture was cured and press-molded at 135°C for

30 minutes. Measurements using this disposable syringe were performed following the same procedures as in Example 27. A sliding resistance value was 0.25 kgf, and a film thickness was 20 to 25 μm . Normal use was allowed in venous injection to a dog. No peeling of the film was found.

Comparative Example 12

It was attempted to assemble a disposable syringe following the same procedures as in Example 27 except that a 4 : 1 (weight ratio) solvent mixture of acetone and dimethylamide was used in place of a coating solution. However, the resultant gasket could not be inserted in a barrel.

Comparative Example 13

It was attempted to dissolve 5% by weight of a polyvinylidene fluoride resin as in Example 27 in ethyl alcohol but the attempt failed. The resultant solution was used as a coating solution to coat a gasket as in Example 27. However, no film was formed on the surface of the gasket and only a granular material was adhered to the surface.

Example 32

100- μm thick polyvinylidene fluoride resin (KYNAR #1120 available from Pennwalt Corp) sheet 20 was heated to 180°C and was placed in female mold 21 shown in Figs. 7A, 7B and 7C. Male mold 22 was then inserted in female mold 21, and the mold assembly was deaerated through gas vent port 23 and a vacuum state was maintained in the mold assembly, thereby obtaining lubricating thin film 7 for a gasket. Unnecessary burs were removed from the molded body, and the resultant molded body was inserted in an injection molding mold. An SEBS elastomer AR-804 available from Aron Kasei K.K. was molded by insert injection to prepare a gasket having a peak diameter of 13.2 mm. A disposable syringe was assembled following the same procedures as in Example 27 except that the above gasket was used. As a result,

a film on the gasket had a sliding resistance value of 0.3 kgf and a thickness of 30 μm . Venous injection to a dog as in Example 27 was performed, and normal use of the syringe was allowed. No peeling of the film was found.

Example 33

A disposable syringe was assembled following the same procedures as in Example 32 except that a polyvinylidene fluoride resin KYNAR #730 available from Pennwalt Corp was used. A film on the gasket had a sliding resistance value of 0.28 kgf and a thickness of 30 μm . Venous injection to a dog was performed, and normal use of the syringe was allowed. No peeling of the film was found.

Example 34

A disposable syringe was assembled and its measurements were performed following the same procedures as in Example 32 except that an EP elastomer Milastomer 5510 available from Mitsui Petrochemical Industries, Ltd. was used in place of the SEBS elastomer. A film had a sliding resistance value of 0.30 kgf and a thickness of 30 μm . Normal use was allowed in venous injection to a dog. No peeling of the film was found.

Comparative Example 14

It was attempted to assemble a disposable syringe following the same procedures as in Example 32 except that a 500- μm thick sheet of a polyvinylidene fluoride resin sheet as in Example 32 was used. However, a gasket could not be inserted in the barrel.

Comparative Example 15

It was attempted to mold a gasket following the same procedures as in Example 32 except that a 20- μm thick polyvinylidene fluoride resin sheet as in Example 32 was used. However, the front end of a gasket was torn, and a perfect gasket was not molded in vacuum molding.

Example 35

A syringe was prepared using two-color injection molding shown in Figs. 4 and 5. 20 phn of a poly-tetrafluoroethylene powder (M-12, available from DAIKIN INDUSTRIES, LTD.) were mixed with high-density polyethylene JX20 available from Mitsubishi Petrochemical Co., Ltd. and the resultant mixture was used as a resin having a low dynamic friction coefficient. An ethylene-propylene copolymer thermoplastic elastomer Milastomer 5510 available from Mitsui Petrochemical Industries, Ltd. (hardness JIS-A: 57, compression set (70°C, 22 hours): 41%) was used as a thermoplastic elastomer. The diameter of a gasket was 13.2 mm. A syringe barrel and a plunger were formed using polypropylene MG35 available from Mitsubishi Petrochemical Co., Ltd. and were combined with a gasket to prepare a syringe. The barrel of the syringe had an inner diameter of 13.0 mm. The resultant gasket and barrel could be assembled with the plunger without using polydimethyl silicone SH200 (3,000 cs) available from Toray Silicone K.K.. After 2.0-Hrad gamma-ray sterilization of the syringe, a 22G cannula was attached to the front end of the syringe. A drug liquid was drawn into the syringe and injected in a muscle of a dog, but no problem occurred.

Comparative Example 16

A syringe was manufactured following the same procedures as in Example 35 except that only a thermoplastic elastomer as in Example 35 was used to form a gasket. Although it was attempted to insert the resultant gasket into a barrel, it was impossible without using silicone oil.

Example 36

Molds were heated to 200°C, a polyvinylidene fluoride powder 460 available from Mitsubishi Petrochemical Co., Ltd. and high-density polyethylene (powder type) as in Example 35 were mixed in a 1 : 1 ratio (weight ratio), and the resultant mixture was

applied to the molds. A thermoplastic elastomer as in Example 35 was injection-molded to prepare a gasket. The thickness of the resin layer having a low dynamic friction coefficient was about 100 μm . The gasket was used to assemble a disposable syringe as in Example 35. No problems occurred.

Example 37

A polyvinylidene fluoride film (100 μm) having increased adhesion strength was prepared by treating a thermoplastic elastomer contact surface with an alkali. The film was compression-molded by molds and adhered thereto, and then an aerosol type epoxy resin was applied to the film. A thermoplastic elastomer was injection-molded following the same procedures as in Example 35, thereby preparing a gasket. A disposable syringe was assembled following the same procedures as in Example 35, and no problems occurred.

Comparative Example 17

A gasket was manufactured following the same procedures as in Example 37 except that a polypropylene film (100 μm) was used in place of the polyvinylidene fluoride film in Example 37. The polypropylene film had a dynamic friction coefficient of 0.9, and the polyvinylidene fluoride film had a dynamic friction coefficient of 0.22. It was attempted to assemble the gasket with the barrel, but syringe assembly was impossible without silicone oil.

Industrial Applicability

According to a disposable syringe according to the present invention as described above, good sliding properties of the plunger can be obtained without using a lubricant, and dissolution of a lubricant in the syringe content can be prevented. The present invention provides a gasket suitable for use in the disposable syringe and a method of manufacturing the same.

Claims:

1. A medical instrument comprising:
a cylindrical member and a sliding member which is adopted to slide along the inner wall of the cylindrical member, wherein the sliding member comprises a thermoplastic elastomer layer and a thermoplastic resin layer of low dynamic friction coefficient covering a portion of the elastomer which contacts with the inner wall of the cylindrical member.
2. A medical instrument according to claim 1, wherein the dynamic friction coefficient of the thermoplastic elastomer layer is 0.5 or less.
3. A medical instrument according to claim 1, wherein the thermoplastic elastomer is at least one copolymer selected from the group consisting of a styrene-butadiene-styrene-based block copolymer, a styrene-ethylene-styrene-based block copolymer, an ethylene-propylene-based copolymer, a polyester-based copolymer and polyurethane-based copolymer.
4. A medical instrument according to claim 1, wherein a compression set (at 70°C for 22 hours) of the thermoplastic resin according to JIS K6301 is not more than 60%.
5. A medical instrument according to claim 1, wherein a hardness value of the thermoplastic elastomer according to JIS K6301 falls within a range of 35° to 85° in JIS-A.
6. A medical instrument according to claim 1, wherein the thermoplastic resin layer of low dynamic friction coefficient is selected from the group consisting of polytetrafluoroethylene (PTFE), polyvinylidene fluoride (PVDF), polytetrafluoroethylene containing a perchloroalkoxy side chain (PFA), polychlorotrifluoroethylene, a tetrafluoro-ethylene-hexafluoropropylene copolymer (FEP), a polyvinylethylene fluoride-ethylene tetrafluoride copolymer, high-density

- 2 -

polyethylene (HDPE), low-density polyethylene having a very high molecular weight, and a material containing at least one thereof.

5 7. A medical instrument according to claim 1, wherein the cylindrical member is a barrel of a syringe, and the sliding member is a gasket of the syringe.

8. A method of manufacturing a medical instrument comprising a cylindrical member and a sliding member which is adopted to slide along an inner wall of the
10 cylindrical member, which comprises the steps of:
placing a base body of the sliding member which is made of an elastic material and has a predetermined shape, in a monomer gas atmosphere; generating a plasma in the atmosphere to perform low-temperature plasma polymeriza-
15 tion of the monomer, thereby forming a fluoroplastic lubricating film on a surface of the base body of the sliding member; and inserting the sliding member into the cylindrical member.

9. A method according to claim 8, wherein the
20 monomer is a fluorine-containing monomer.

10. A method according to claim 8, wherein a low-temperature plasma polymerization pressure in a reaction system falls within a range of 10^{-3} to 10 Torr.

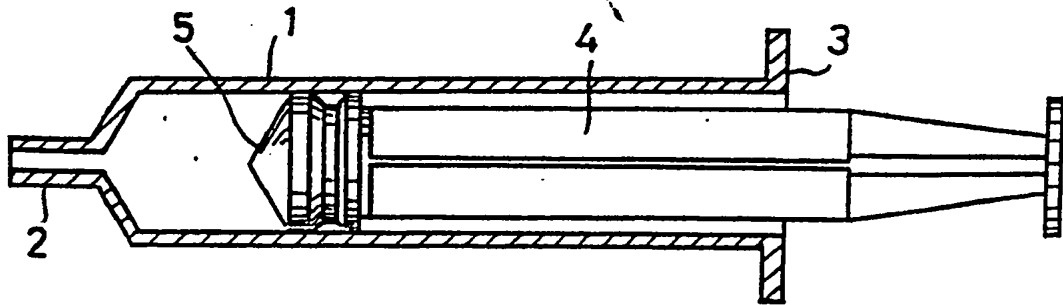


Fig. 1.

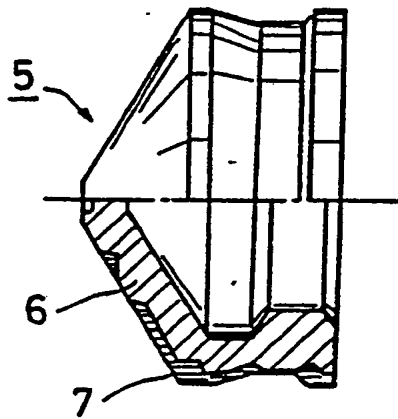


Fig. 2.

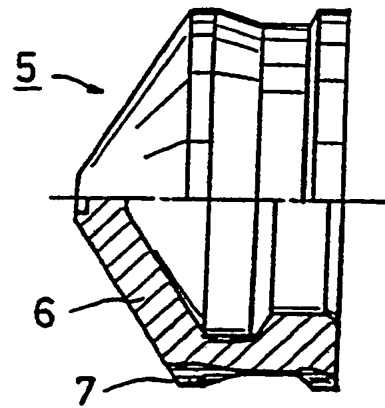


Fig. 3.

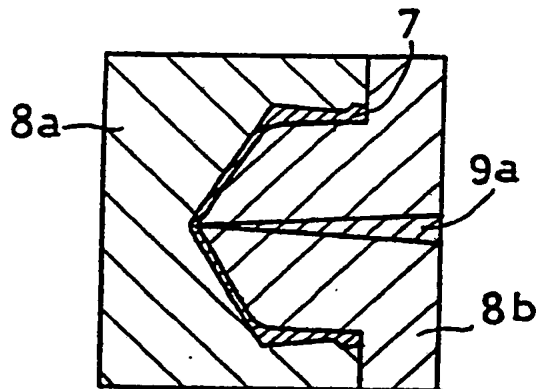


Fig. 4.

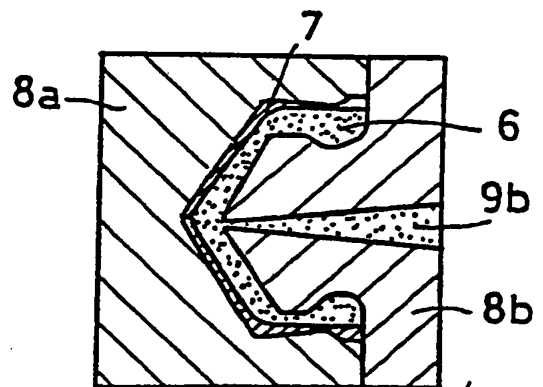


Fig. 5. ✓

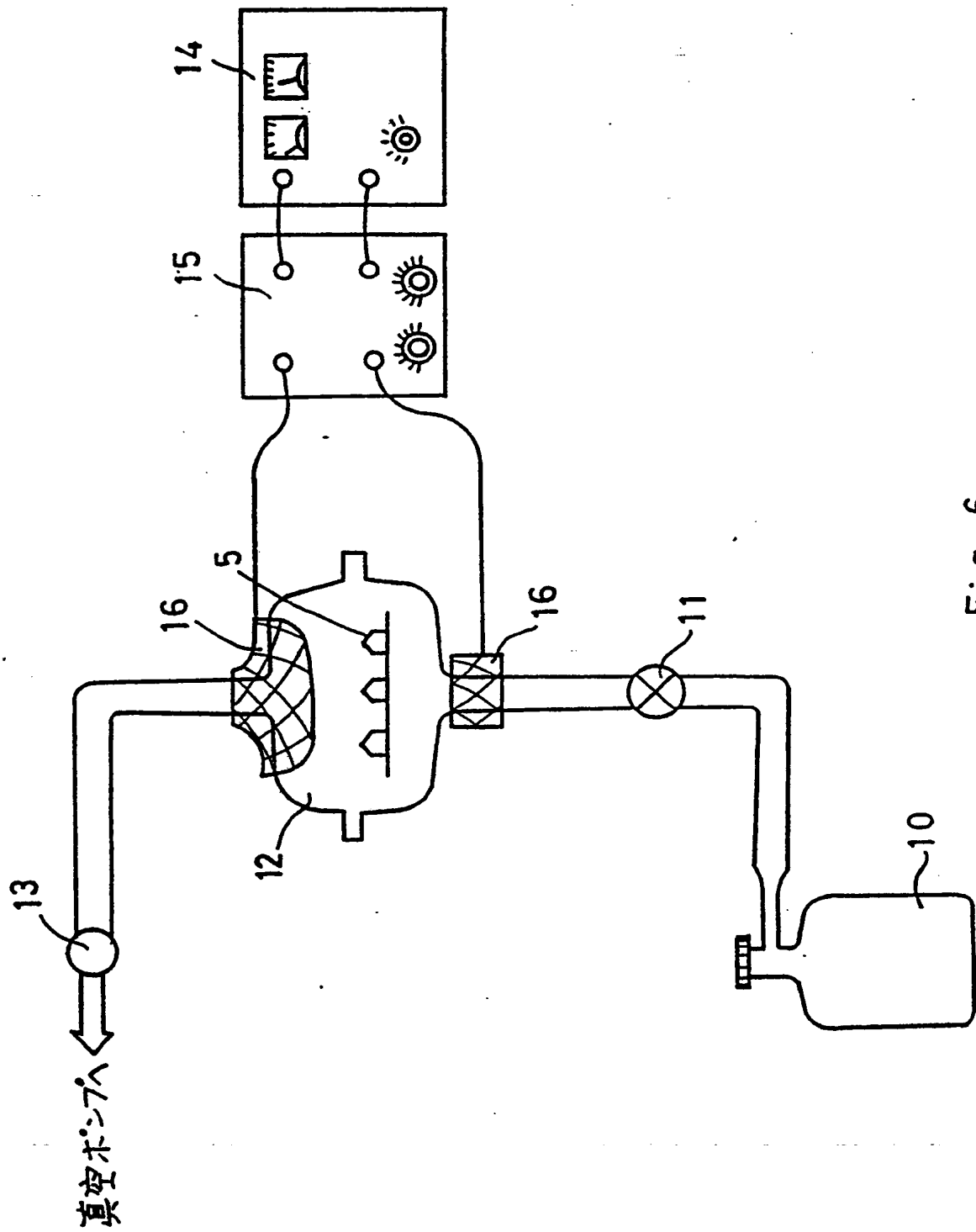


Fig. 6.

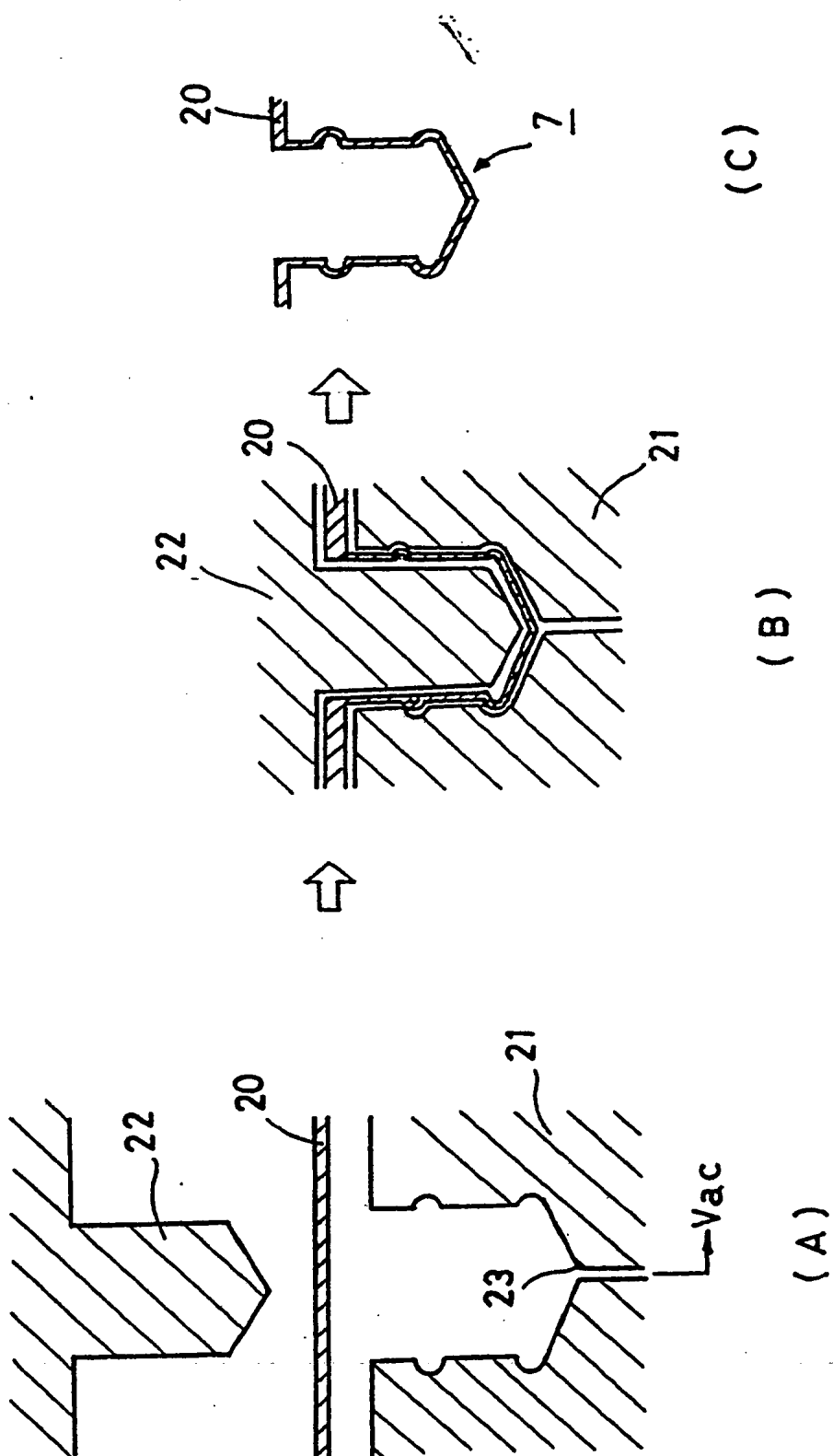


Fig. 7.

INTERNATIONAL SEARCH REPORT

International Application No. PCT/JP88/00593

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) ⁴ According to International Patent Classification (IPC) or to both National Classification and IPC <div style="display: flex; justify-content: space-between; margin-top: 10px;"> Int.Cl⁴ A61M5/315 </div>											
II. FIELDS SEARCHED <div style="text-align: center; margin-top: 10px;">Minimum Documentation Searched ¹</div> <table border="1" style="width: 100%; border-collapse: collapse; margin-top: 5px;"> <tr> <th style="width: 25%;">Classification System</th> <th style="width: 75%;">Classification Symbols</th> </tr> <tr> <td style="text-align: center; padding: 10px;">IPC</td> <td style="text-align: center; padding: 10px;">A61M5/315</td> </tr> </table> <div style="text-align: center; margin-top: 10px;">Documentation Searched other than Minimum Documentation to the Extent that such Documents are included in the Fields Searched ¹</div> <div style="display: flex; justify-content: space-between; margin-top: 10px;"> <div style="width: 45%;"> Jitsuyo Shinan Koho Kokai Jitsuyo Shinan Koho </div> <div style="width: 50%;"> 1950 - 1988 1971 - 1988 </div> </div>			Classification System	Classification Symbols	IPC	A61M5/315					
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III. DOCUMENTS CONSIDERED TO BE RELEVANT ³ <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 10%;">Category ⁵</th> <th style="width: 70%;">Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²</th> <th style="width: 20%;">Relevant to Claim No. ¹³</th> </tr> </thead> <tbody> <tr> <td style="text-align: center; vertical-align: top;">X</td> <td style="vertical-align: top;">JP, U, 57-176244 (Eguchi Take) 8 November 1982 (08. 11. 82) Page 1 (Family: none)</td> <td style="text-align: center; vertical-align: top;">1-5</td> </tr> <tr> <td style="text-align: center; vertical-align: top;">X</td> <td style="vertical-align: top;">JP, U, 55-70151 (Eguchi Take) 30 April 1980 (30. 04. 80) Page 1 (Family: none)</td> <td style="text-align: center; vertical-align: top;">1-10</td> </tr> </tbody> </table>			Category ⁵	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³	X	JP, U, 57-176244 (Eguchi Take) 8 November 1982 (08. 11. 82) Page 1 (Family: none)	1-5	X	JP, U, 55-70151 (Eguchi Take) 30 April 1980 (30. 04. 80) Page 1 (Family: none)	1-10
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¹⁰ Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed		"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "Z" document member of the same patent family									
IV. CERTIFICATION <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%; padding: 5px;"> Date of the Actual Completion of the International Search <div style="text-align: center; margin-top: 10px;">August 29, 1988 (29. 08. 88)</div> </td> <td style="width: 50%; padding: 5px;"> Date of Mailing of this International Search Report <div style="text-align: center; margin-top: 10px;">September 19, 1988 (19. 09. 88)</div> </td> </tr> <tr> <td style="width: 50%; padding: 5px;"> International Searching Authority <div style="text-align: center; margin-top: 10px;">Japanese Patent Office</div> </td> <td style="width: 50%; padding: 5px;"> Signature of Authorized Officer Examiner of Patent Office <div style="display: flex; justify-content: space-between; margin-top: 5px;"> Toru YASUDA (seal) </div> </td> </tr> </table>			Date of the Actual Completion of the International Search <div style="text-align: center; margin-top: 10px;">August 29, 1988 (29. 08. 88)</div>	Date of Mailing of this International Search Report <div style="text-align: center; margin-top: 10px;">September 19, 1988 (19. 09. 88)</div>	International Searching Authority <div style="text-align: center; margin-top: 10px;">Japanese Patent Office</div>	Signature of Authorized Officer Examiner of Patent Office <div style="display: flex; justify-content: space-between; margin-top: 5px;"> Toru YASUDA (seal) </div>					
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